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# Design and Construction of a Micro Controller Based Smart Automated System for Controlling Various Home Appliances

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**ABSTRACT**: *Smart Home Automated System is an inexpensive technology. This study presents the overall design of Home Automation System (HAS) with low cost and wireless system. This system is designed to assist and provide support in order to fulfill the needs of elderly and disabled in home. Also, the smart home concept in the system improves the standard of living at home. The sensors, relays and web browser are used to control the home appliances. The main control system implements wireless technology to provide remote access from smart phone. The design removes the existing electrical switches and provides more safety control on the switches with low voltage activating method. The system intends to control electrical appliances and devices in house with relatively low cost design, user- friendly interface and ease of installation. Alternatively, SMART HOME AUTOMATED SYSTEM can provide higher level of security and convenience compared to traditionally used systems. The main objective of the current paper is to design and implement cost-efficient and reliable security, safety and automatic home system for protection and occupants' convenience. If any hazard is being sensed like smoke, excess heat, unauthorized movements etc; the system warns the home-owner in real-time using Short Message Service (SMS). With this project, home appliances can also be controlled within and away from home, at the same time gives access to real time monitoring of the appliances and properties.*

**KEYWORD:** smart home, automated system, bluetooth, WI-FI, Internet of Things (IoT)

## INTRODUCTION

A smart home or building is a house or building, usually a new one that is equipped with special structured wiring to enable occupants to remotely control or program an array of automated home electronic devices by entering a single command (Sripan, 2012). Smart homes contain multiple, connected devices such as home entertainment consoles, security systems, lighting, access control systems and surveillance (Redriksson, V., 2015). Intelligent home automation system is incorporated into smart homes to provide comfort, convenience, and security to home owners.

Home automation system represents and reports the status of the connected devices in an intuitive, user-friendly interface allowing the user to interact and control various devices with the touch of a few buttons. In the near future, it is estimated that somewhat 90 million people around the world will live in smart homes, using technology to improve home security, comfort, and energy usage (Aldrich, F., 2003).

Smart home automation is a prime example of a smart environment built on various types of cyber-physical systems generating volumes of diverse, heterogeneous, complex, and distributed data from a multitude of applications and sensors. Therefore, such home automation is also an example of an Internet of Things (IoT) scenario, where a communication network extends the present internet by including everyday items and sensors, which in this case includes the possibility to monitor and manage energy usage (Jin, C., 2011). As such, smart home automation systems incorporate common devices that control features of the home, but they do not only turn devices on and off. For instance, smart home automation systems can monitor the configuration of the internal environment and the activities that are being undertaken whilst the house is occupied (and unoccupied). The result of these modifications to the technology is that a smart home automation system can autonomously operate devices and thus manage the home on behalf of the end-users, i.e. humans (Kaur, I., 2010). Some of the major communication technologies used by today's home automation system include;

Bluetooth, WiMAX and Wireless LAN (Wi-Fi), Zigbee, and Global System for Mobile Communication (GSM) (Robles, 2010). There are three generations of home automation: First generation: wireless technology with proxy server, e.g. ZigBee automation; Second generation: artificial intelligence controls electrical devices, e.g. Amazon Echo; Third generation: robot buddy who interacts with humans, e.g. Robot Rovio, Roomba (Li et al., 2016).

Due to the advancement of wireless technology, there are several different types of connections that are introduced such as GSM, WIFI, and Bluetooth. Each of the connection has its own unique specifications and applications. Among the four popular wireless connections that are often implemented in home automation system projects, WIFI is being chosen with its suitable capability.

The capabilities of WIFI are more than enough to be implemented in this design. Also, most of the current laptop/notebook or Smartphone come with built-in WIFI adapter (ElShafee, A. & Hamed, K. A., 2012). It will indirectly reduce the cost of this system.

**Statement of Problem**

Home automation has been a feature of science fiction for many years, and began to be put into practice in the early 20th century. Despite the great interest, however, problems have limited the venture of home automation into the homes of the rich or hobbyists, among them including complexity, high costs, and multiple

incompatible standards.

This study intends to encourage the use of home automation systems in all classes of homes, through the design of a low cost, easy to use, and open source home automation system; ultimately helping in providing a convenient, energy efficient, and secure environment for the society.

**Aims and Objectives**

The aim of the study is to design a home automation system using Arduino NANO, ESP32 Wi-Fi module and GSM module as an open source platform for all end users.

The objectives of the study are as follows:

- To design a microcontroller-based system that effectively controls and monitors devices in the home system.
- To develop a remote control system based on the design that enables appliances control through the internet using Wi-Fi and an IP address.
- To design a system with feedback control using GSM module.
- To construct a system that is user friendly and easy to use.
- To test the system to ensure it is functioning as planned.

**Scope and Limitation of Study**

The aim of this study is to design an open source, easy-to-use and affordable home automation system. For this reason, the Arduino microcontroller is used, acting as the main controller for the system by sending signals to control electronic appliances. The study was limited to a home model for prototyping purposes. A web browser works as the user interface while a standard Wi-Fi network is used as the medium between the microcontroller (ESP 8266) and web browser.

## LITERATURE REVIEW

Review of Existing Home Automation Systems

Different types of approaches have been made towards home automation. An SMS based method uses GSM technology available in phones to communicate with a microcontroller which acts as the main control for access to home appliances. A GSM module is also required to be attached to the microcontroller through a port

to enable SMS capability (Khiyal, 2009). The disadvantage of such a system is that it is not user friendly, as there is no graphical user interface, and access codes and command codes must be remembered to operate the system.

Another approach focuses on voice recognition to send commands through a wireless radio frequency network. The voice command is captured using a microphone, digitalized, and sent to a computer to be processed by a program based on Visual Basic which employs Microsoft speech API. Upon recognition of the voice command, control signals are sent to the specified appliance addresses for action (Schaefer, 2014). The tested system however was not always accurate in recognizing voice commands.

"A System for Smart-Home Control of Appliances based on Time and Speech Interaction" was another approach taken that controls the home appliances using a personal computer. This system is developed by using the Visual Basic 6.0 as programming language and Microsoft voice engine tools for speech recognition purpose. Appliances can be either controlled by timer or by voice command.

Hand gestures were also proposed as control for home automation systems. A small camera is worn as a necklace to observe the various gestures made by a user's hand in order to interpret and send command signals. The use of such technology, however, requires the use of a high end PC for data processing, resulting in a higher setup cost.

**Hardware used in the design of the study**

**Arduino NANO**

The term Arduino covers the hardware, software, development team, design philosophy, and morale of the user community. Originally developed in Ivrea, Italy, Arduino was named after the king of Italy about 1000 years ago, "Arduino of Ivrea". The name Arduino is a masculine Italian name meaning "strong friend", and is always capitalized being a proper name. The Arduino I/O Board is the physical, tangible part of the Arduino system. The board is based on the Atmel AVR ATmega8 microprocessor and later derivatives containing a serial port, power supply circuitry, expansion connectors, and various support components.

For this study the Arduino NANO, a board based on the ATmega328 microcontroller was used.

**Figure 1.0: An Arduino NANO board**

Arduino Nano is a small, compatible, flexible and breadboard friendly Microcontroller board, developed by

Arduino.cc in Italy, based on ATmega328p (Arduino Nano V3.x) / Atmega168 (Arduino Nano V3.x). It comes with exactly the same functionality as in Arduino UNO but quite in small size. It has an operating voltage of 5V, however, the input voltage can vary from 7 to 12V. Arduino Nano Pinout contains 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins. Each of these Digital & Analog Pins are assigned with multiple functions but their main function is to be configured as input or output. They act as input pins when they are interfaced with sensors. This board does not use standard USB for connection with a computer, it rather comes with Mini USB support. It has a flash memory of 16KB or 32KB that all depends on the Atmega board i.e. Atmega168 comes with 16KB of flash memory while Atmega328 comes with a flash memory of 32KB, which is used for storing code. A 2KB memory out of total flash memory is used for a bootloader. The SRAM can vary from 1KB or 2KB and EEPROM is 512 bytes or 1KB for Atmega168 and Atmega328 respectively.

**The following figure shows the pinout of Arduino Nano Board:**

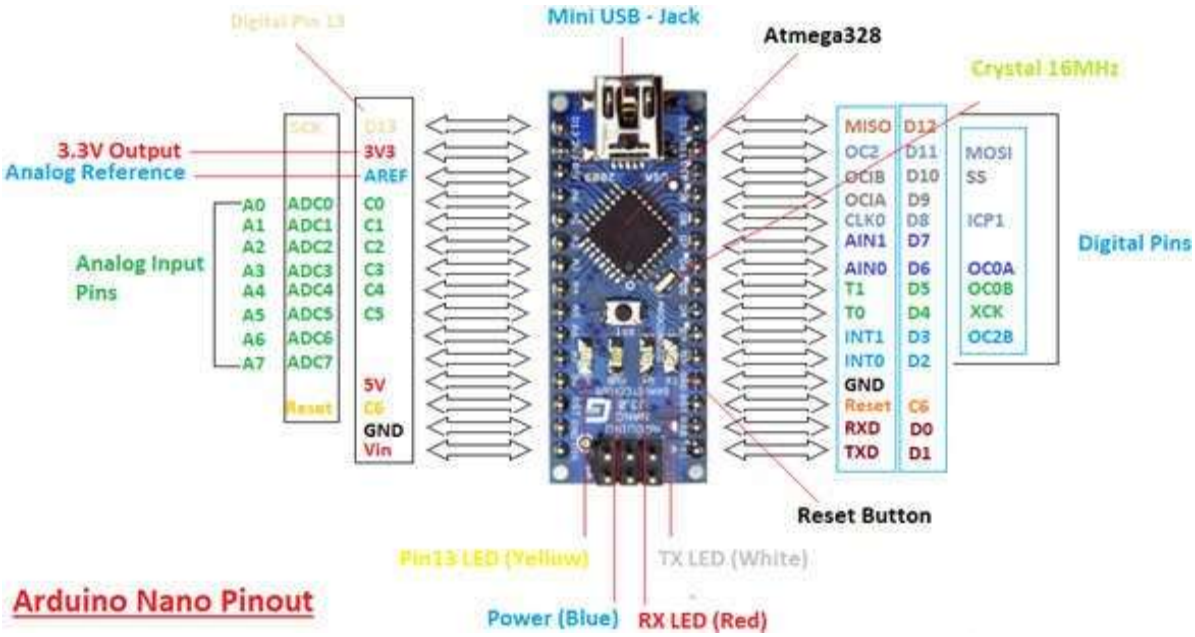



Figure 1.1: Pinout of the Arduino NANO board Pin description

- Vin: It is the input power supply voltage to the board when using an external power source of 7 to 12 V.
- 5V: It is a regulated power supply voltage of the board that is used to power the controller and other components placed on the board.
- 3.3V: This is a minimum voltage generated by the voltage regulator on the board.
- GND: These are the ground pins on the board. There are multiple ground pins on the board that can be interfaced accordingly when more than one ground pin is required.
- Reset: Reset pin is added on the board to reset the board when a running program goes too complex and hangs up the board. LOW value to the reset pin will reset the controller.
- Analog Pins: There are 8 analog pins on the board marked as A0 – A7. These pins are used to measure the analog voltage ranging between 0 to 5V.
- Rx, Tx: These pins are used for serial communication where Tx represents the transmission of data while Rx represents the data receiver.
- Pin 13: This pin is used to turn on the built-in LED.
- AREF: This pin is used as a reference voltage for the input voltage.
- PWM: Six pins 3, 5, 6,9,10, 11 can be used for providing 8-bit PWM (Pulse Width Modulation) output. It is a method used for getting analog results with digital sources.

- SPI: Four pins 10(SS),11(MOSI),12(MISO),13(SCK) are used for SPI (Serial Peripheral Interface). SPI is an interface bus and mainly used to transfer data between microcontrollers and other peripherals like sensors, registers, and SD card.
- External Interrupts: Pin 2 and 3 are used as external interrupts which are used in case of emergency when we need to stop the main program and call important instructions at that point. The main program resumes once interrupt instruction is called and executed.
- I2C: I2C communication is developed using A4 and A5 pins where A4 represents the serial data line (SDA) which carries the data and A5 represents the serial clock line (SCL) which is a clock signal, generated by the master device, used for data synchronization between the devices on an I2C bus.

**Communication and programming of the Arduino NANO**

The NANO device comes with an ability to set up a communication with other controllers and computers. The serial communication is carried out by the digital pins like pin 0 (Rx) and pin 1 (Tx), where Rx is used for receiving data and Tx is used for the transmission of data. The serial monitor is added on the Arduino software which is used to transmit textual data to or from the board. FTDI drivers are also included in the software which behaves as a virtual com port to the software.

The Tx and Rx pins come with an LED which blinks as the data is transmitted between FTDI and USB connection to the computer. Arduino Software Serial Library is used for carrying out a serial communication between the board and the computer. Apart from serial communication the Nano board also supports I2C and SPI communication. The Wire Library inside the Arduino Software is accessed to use the I2C bus.

The Arduino Nano is programmed by Arduino Software called IDE which is a common software used for almost all types of board available. Simply download the software and select the board you are using. There are two options to program the controller i.e. either by the bootloader that is added in the software which sets you free from the use of external burner to compile and burn the program into the controller and another option is by using ICSP (In-circuit serial programming header). The board software is equally compatible with Windows, Linux or MAC, however, Windows are however preferred in use.

**ESP 32s**

**Figure 1.2: ESP 32s Wi-Fi board**

**Description:**

ESP32 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations and includes in-built antenna switches, RF balun, power amplifier, low- noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process. It is a successor to the ESP8266 microcontroller.

Features of the ESP32 include the following:

Processors:

CPU: Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, operating at160 or 240 MHz and performing at up to 600 DMIPS

Ultra low power (ULP) co-processor

Memory: 160 KiB static allocated + 160 KiB dynamic allocated DRAMWireless

connectivity:

Wi-Fi: 802.11 b/g/n

Bluetooth: v4.2 BR/EDR and BLE

Peripheral interfaces:

12-bit SAR ADC up to 18 channels2 ×

8-bit DACs

10 × touch sensors (capacitive sensing GPIOs)4 ×

SPI

2 × I²S interfaces

2 × I²C interfaces

3 × UART

SD/SDIO/CE-ATA/MMC/eMMC host controller

SDIO/SPI slave controller

Ethernet MAC interface with dedicated DMA and IEEE 1588 Precision TimeProtocol support

CAN bus 2.0

Infrared remote controller (TX/RX, up to 8 channels)Motor

PWM

LED PWM (up to 16 channels)
Hall effect sensor

Ultra low power analog pre-amplifier

Security:

IEEE 802.11 standard security features all supported, including WFA,WPA/WPA2 and WAPI

Secure boot

Flash encryption

1024-bit OTP, up to 768-bit for customers

Cryptographic hardware acceleration: AES, SHA-2, RSA, elliptic curvecryptography (ECC), random number generator (RNG)

Power management:

Internal low-dropout regulator

Individual power domain for RTC

5µA deep sleep current

Wake up from GPIO interrupt, timer, ADC measurements, capacitive touch sensorinterrupt

**Relay module**

A relay is an electrical device which is generally used to control high voltages using very low voltage as an Input. This consists of a coil wrapped around a pole and a two small metal flaps(nodes) that are used to close the circuit. One of the node is fixed and other is movable. Whenever an electricity is passed through the coil, it creates a magnetic field and attracts the moving node towards the static node and the circuit gets completed. So, just by applying small voltage to power up the coil we can actually complete the circuit for the high voltage to travel. Also, as the static node is not physically connected to the coil there is very less chance that the Microcontroller powering the coil gets damaged if something goes wrong.

Below is a relay module:


**Fig 1.3: Relay module**

This is a four-channel relay board controlled by computer USB port. Suitable for home automation applications, hobby, projects and industrial automation. Examples of software that can be used to program the relay module are in lab view, .NET, Java, Borland C++, Python.

**Features:**

- Power led: Yes
- Relay led: YesHigh quality
- 4 SPDT Relay channels - selectable by user
- PCB parameters: FR4 / 1.5mm / two layers / metalized holes / HAL / white
- Stamp / solder mask / extra PCB openings for better voltage isolation / doubled high voltage tracks
- Android software available (low cost but very useful): Yes

**A6 Mini GSM Module**

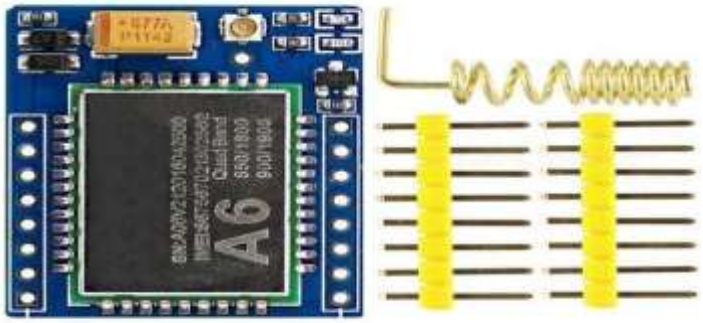



**Figure 1.4: A6 mini GSM module**

**Description:**

This is mini version serial GSM / GPRS core development board based on GPRS A6 module. It supports dual-band GSM/GPRS network, available for GPRS and SMS message data remote transmission. The board features compact size and low current consumption. With power saving technique, the current consumption is as low as 3mA in sleep mode. It communicates with microcontroller via UART port, supports command including GSM 07.07, GSM 07.05 and Ai-Thinker enhanced AT Commands.

The A6 GSM module has total 24 pins that interface it to the outside world. The connections are as follows:


**Figure 1.5: A6 mini GSM module pinout**

- VCC: supplies power for the module. Connect this to any external powersource rated 5V 2A.
- GND: is the Ground Pin and needs to be connected to GND pin on theArduino.
- MIC±: is a differential microphone input. The two microphone pins can be connected directly to these pins.
- EAR_R: is used to interface 4-pole TRRS Headset
- EAR_L: is used to interface 4-pole TRRS Headset
- HST_RXDHOST UART: is a debug UART, which is used for downloading, calibrating, trace and so on. It doesn't support any AT command. Thisinterface is only used when debugging
- HST_TXD UART: is a debug UART, which is used for downloading, calibrating, trace and so on. It doesn't support any AT command. Thisinterface is only used when debugging
- RST: (Reset) is a hard reset pin. If you absolutely got the module in a bad space, pull this pin low for 100ms to perform a hard reset.
- NC: Not Connected
- PWR pin: is used for turning module ON/OFF programmatically. For doing this you must pull it HIGH for a moment (less than 500 ms or around).

**Specifications:**

- LED Working temperature -30 ° to + 80 °
- Operating Voltage 5V
- Standby average current 3ma less
- Support the GSM / GPRS four bands, including 850,900,1800,1900MHZ

- GPRS Class 10
- Sensitivity <-105
- Support voice calls
- Support SMS text messaging
- Support GPRS data traffic, the maximum data rate,
- Supports standard GSM07.07,07.05 AT commands and extended commandsAi Thinker
- Supports two serial ports, a serial port to download an AT command port
- AT command supports the standard AT and TCP / IP command interface
- Support digital audio and analog audio support for HR, FR, EFR, AMRspeech coding
- Support ROHS, FCC, CE, CTA certification
- SMT 42PIN package

## Methodology and Design

This session explains methods and design process used in this study as well as the block diagram and individual stages of the device. Also, it shows the mathematical calculation that determined choice of components and their respective values.

### System and Component Review

For easy comprehension, the components of the system used for the study are briefly discussed below;

Power Supply Unit: A power supply is an electrical device that supplies electric power to an electric load. The type of power supply used in the block diagram is a 12 volt sealed battery of 7.2AH. This battery supplies the total power needed for the electronic circuit to function.


**Figure 1.6: A 12Volts rechargeable sealed lead-acid Battery.**

**Arduino Microcontroller**: Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 8 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

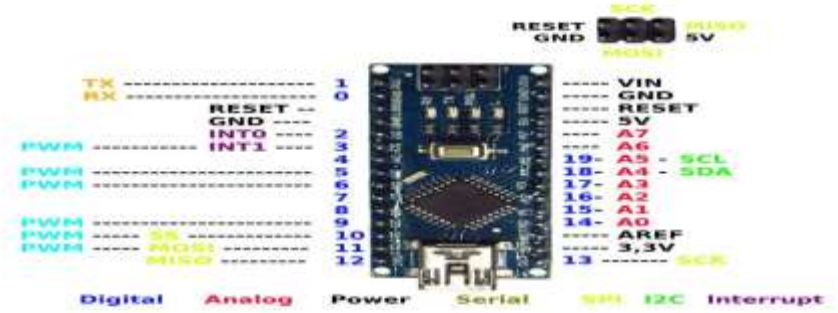



**Figure 1.7: Arduino NANO microcontroller**

It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The ATmega328 on the Arduino NANO comes preprogrammed witha bootloader that allows you to upload new code to it without the use of an external hardware programmer. The Arduino Nano can be programmed with the Arduino Software (INTEGRATED DEVELOPMENT ENVIRONMENT (IDE)). The Nano differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

**Sensors:** A sensor is a device which detects or measures a physical property and records, indicates, or otherwise responds to it. The sensors implemented in this study are the temperature sensor, passive infrared motion sensor and the light dependent resistor.

- **Temperature sensor:** A temperature sensor is a device, typically, a thermocouple or RTD or Semiconductor-based sensors, that provides for temperature measurement through an electrical signal. The type of temperature sensor used is a semiconductor-based sensor ds18b20. A semiconductor-basedtemperature sensor is placed on integrated circuits (ICs). These sensors are

effectively two identical diodes with temperature-sensitive voltage vs current characteristics that can be used to monitor changes in temperature. They offer a linear response but have the lowest accuracy of the basic sensor types at 1 °C to5 °C. They also have the slowest responsiveness (5 s to 60 s) across the narrowest temperature range (-70 °C to 150 °C).

**Figure 1.7: temperature sensor**

- **Passive infrared motion sensor**: A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications. PIR sensors detect general movement, but do not give information on who or what moved.

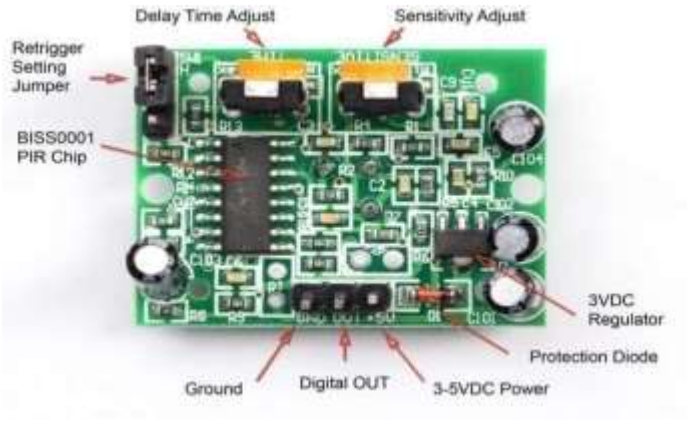



**Figure 1.8: PIR sensor**

- **Light dependent resistor:** A photo resistor is a light-controlled variableresistor. The resistance of a photo resistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photo resistor can be applied in light-sensitive detector circuits, light-activated and dark- activated switching circuits.

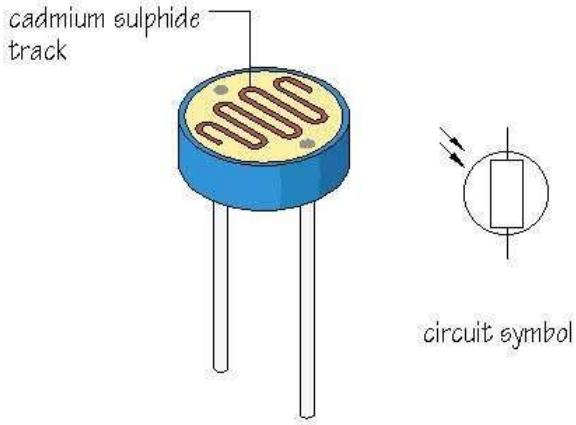



**Figure 1.9: A light dependent resistor**

**Relays:** A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.


**Figure 2.0: 4 Channel Relay**

**Light Emitting Diode (LED):** A light emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layerof light-emitting phosphor on the semiconductor device.

**Figure 2.1: Light emitting diode**

**Servo motor:** A Servo is a small device that incorporates a two wire DC motor, a gear train, a potentiometer, an integrated circuit, and an output shaft. A typical Servo looks like a rectangular box with a motor shaft coming out of one end and a connector with three wires out of the other end. Of the three wires that stick out from the motor casing, one is for power, one is for ground, and one is a control input line. The shaft of the servo can be positioned to specific angular positions by sending a coded signal. As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft. If the coded signal changes, then the angular position of the shaft changes Servos work with voltages between 4and 6 volts.

**Figure 2.2: Micro servo motor**

**A6 mini GSM module:** A6 GSM/GPRS module is a miniature GSM modem, which can be integrated into a great number studies on IoT. This module can be used to accomplish almost anything a normal cell phone can; SMS text messages, make or receive phone calls and connecting to internet through GPRS, TCP/IP. This module also supports quad-band GSM/GPRS network, meaning it works almost anywhere in the world.

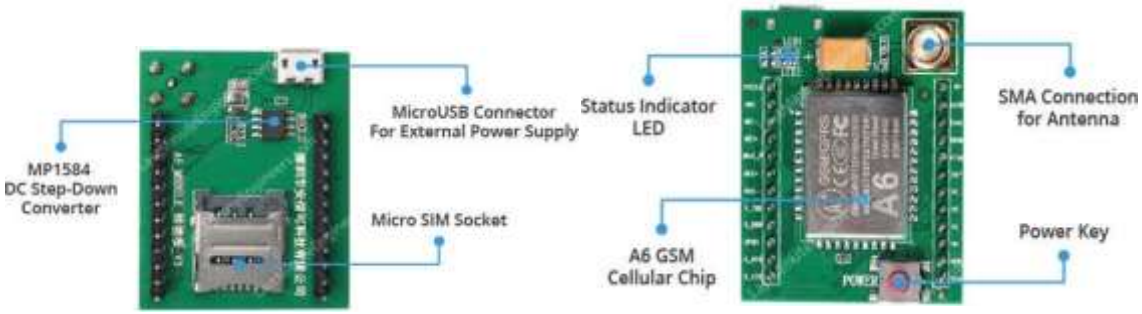



**Figure 2.3: A6 mini GSM module**

**ESP32 Wi-Fi camera:** The ESP32-CAM is a very small camera module withthe ESP32-S chip. It

has an OV2640 camera and several GPIOs to connect peripherals. It also features a micro SD card slot that can be useful to store images taken with the camera or to store files to serve to clients.


**Figure 2.4: ESP32 cam Wi-Fi camera**

**ESP 32S WI-FI Micro-controller:** ESP32 is a series of low-cost, low- power system on a chip microcontroller with integrated Wi-Fi and dual- mode Bluetooth. The ESP32 series employs a Ten silica Xtensa LX6microprocessor in both dual and single core variations and includes in-built antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters and power-management modules.

**Figure 2.5: ESP32s Wi-Fi Bluetooth micro-controller**

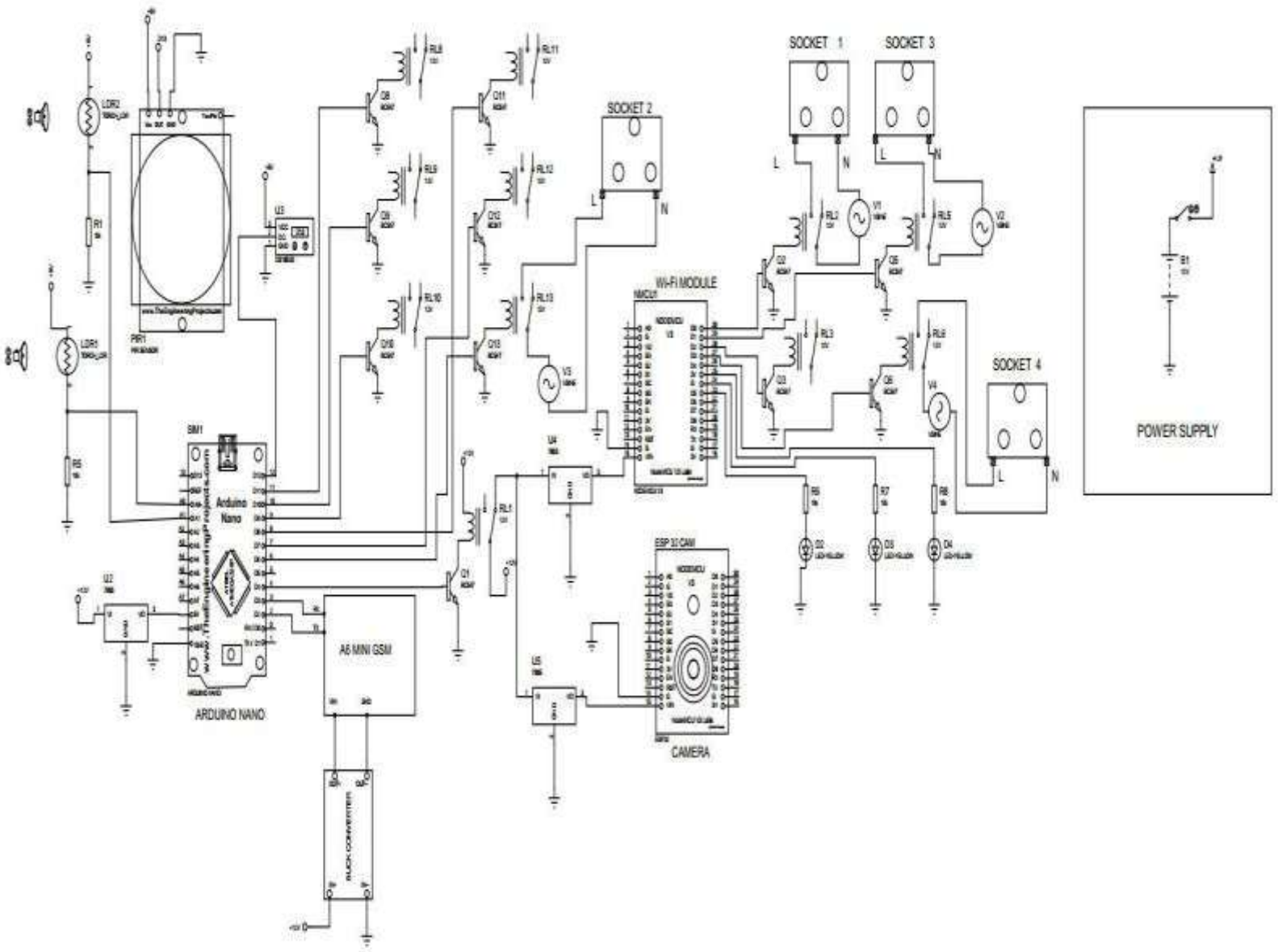



**Figure 2.6: Complete circuit diagram**

After designing the software and the hardware architecture part, we implemented the working circuit diagram on the breadboard/ project board and also on proteus simulation software for testing purpose. First we tested the sensors which are the temperature sensor DS18b20 and light dependent resistor LDR in the proteussimulation software and uploaded/compile the code which was written with the Arduino IDE software into the microcontroller for testing.

**Circuit Diagram of the Sensors**

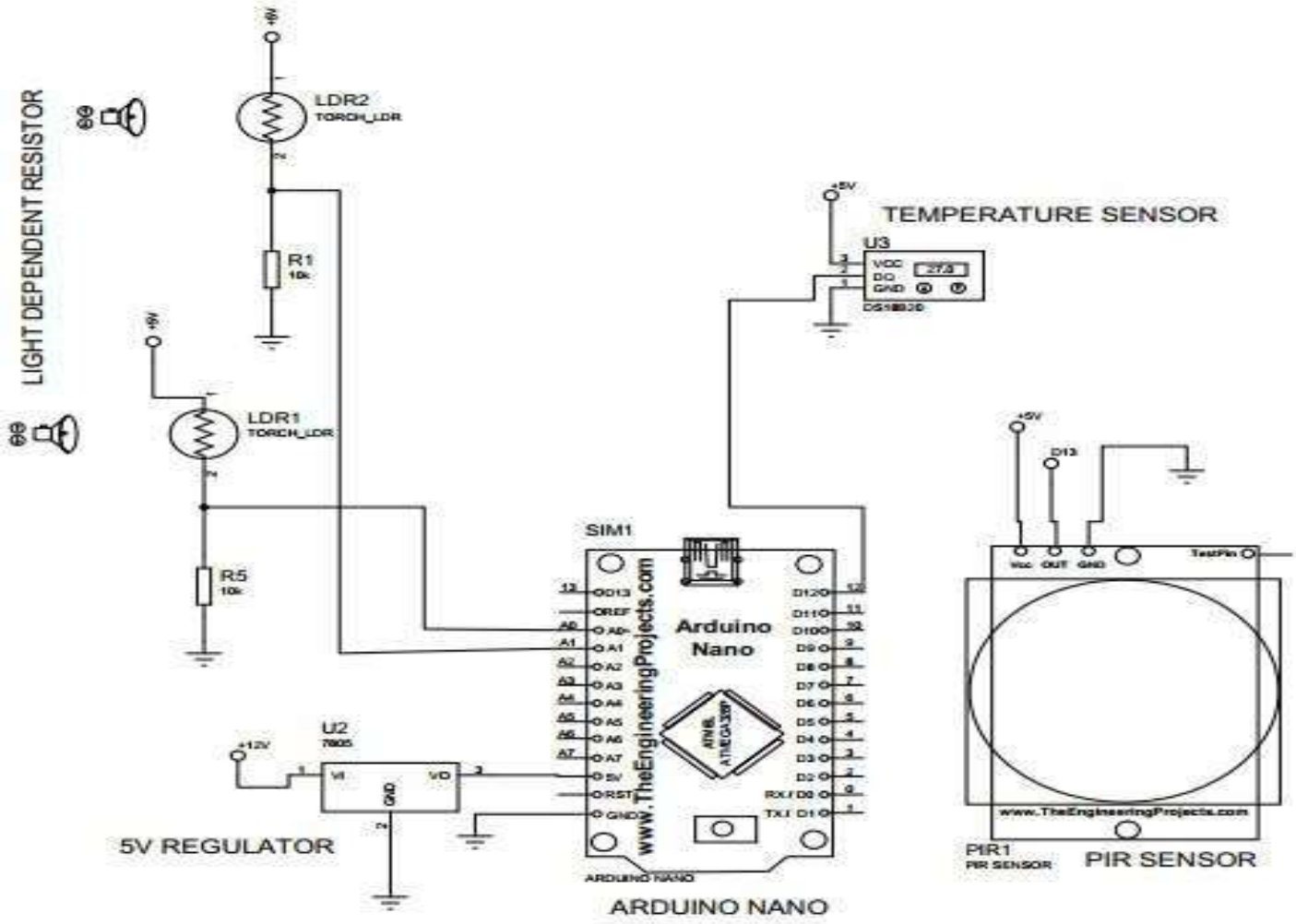
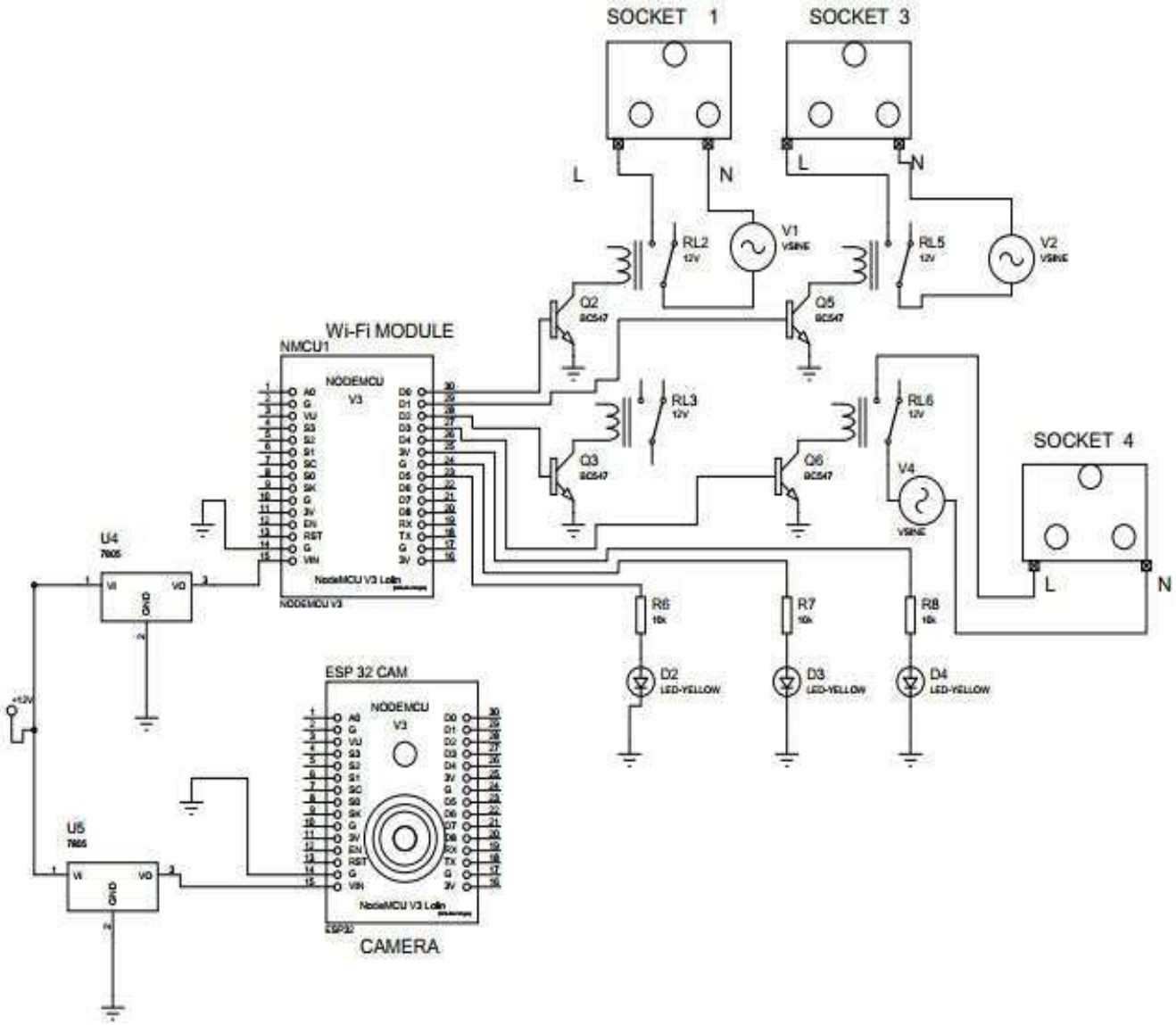



**Figure 2.7: Arduino Nano connected to three sensors for home automation**




**2.8 Circuit Diagram of Appliances Controlled over WI-FI**

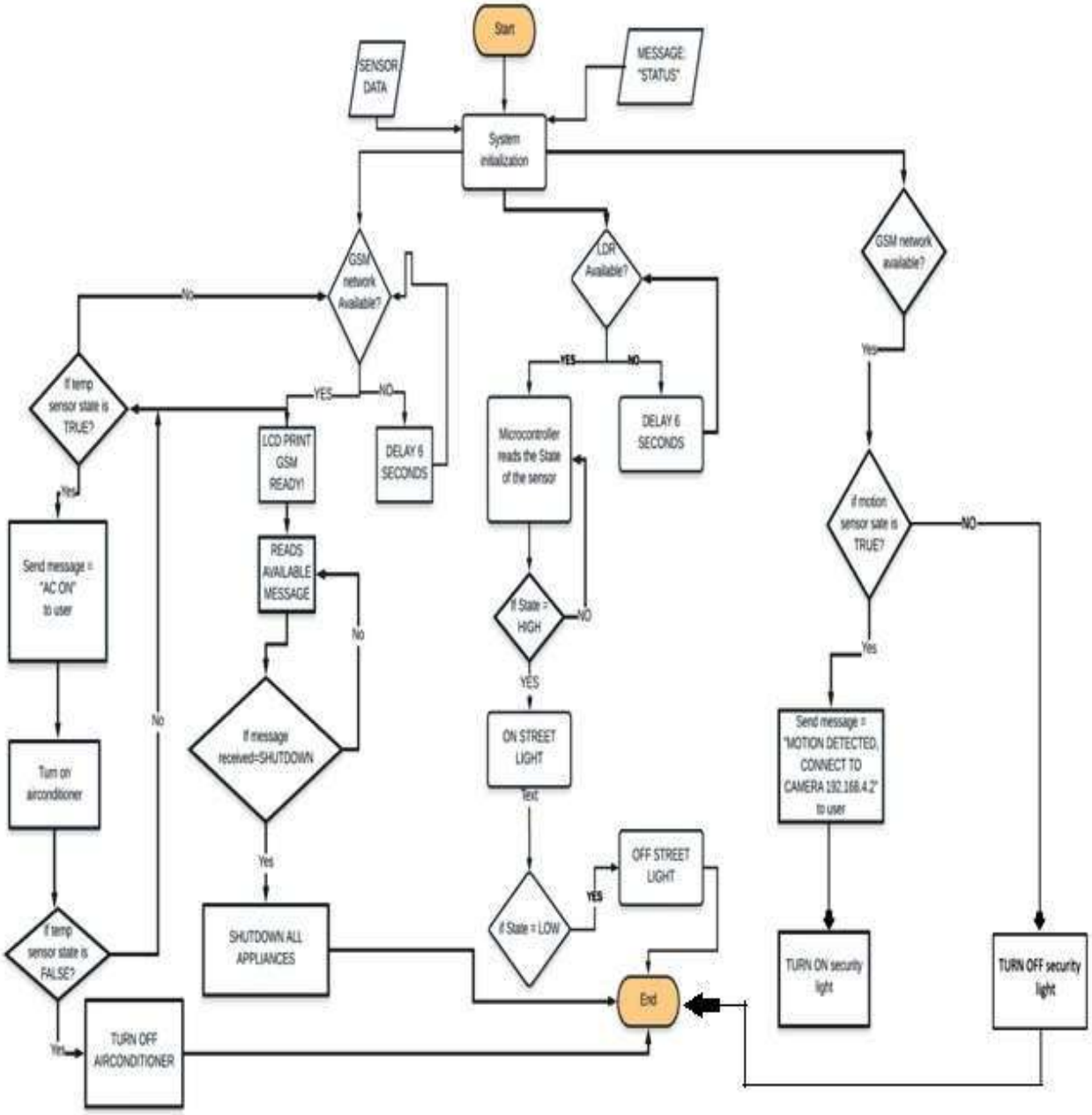



**Figure 2.9: Flow chart of automatic home control**

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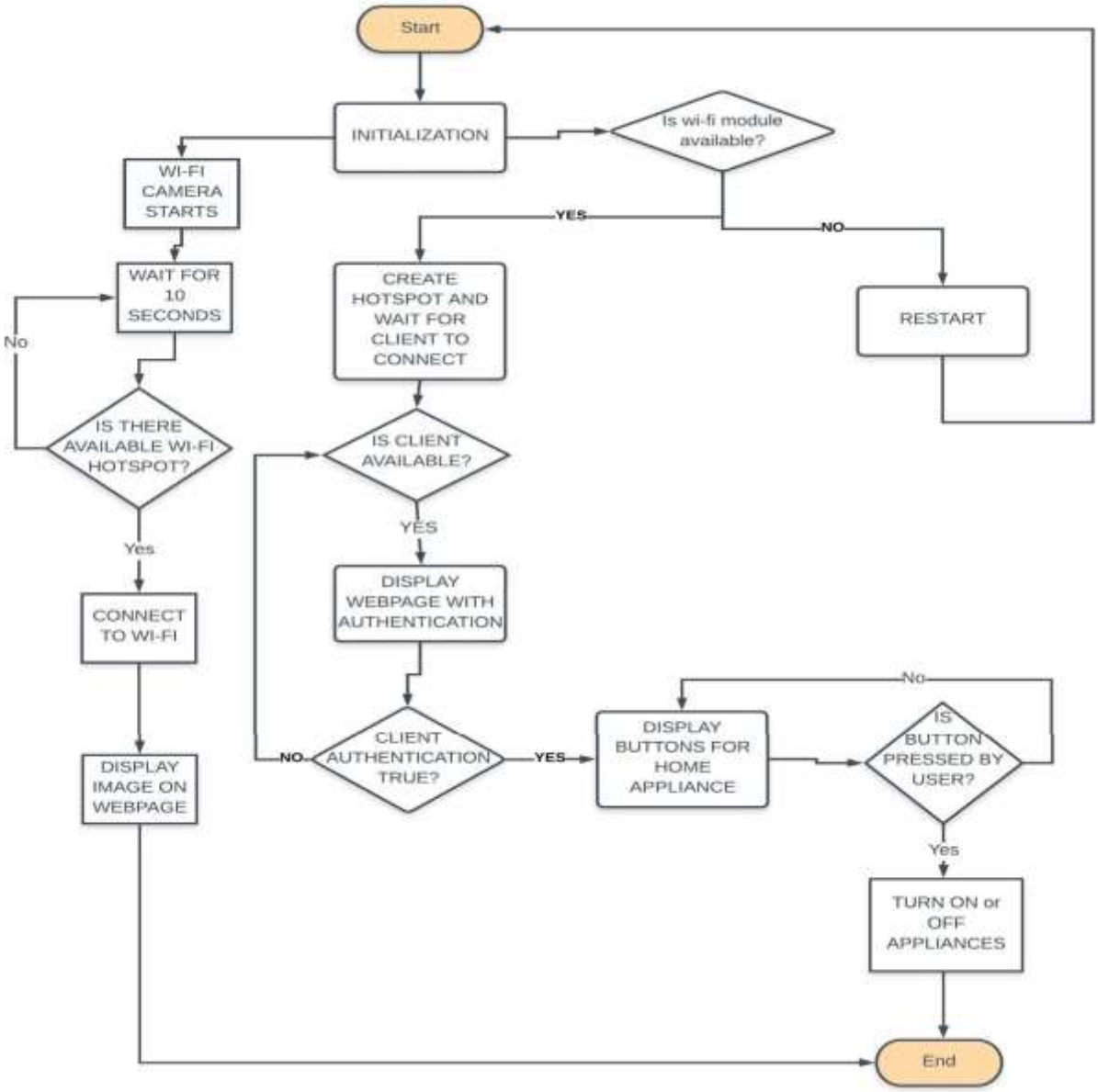


**Figure 3.0: flowchart of Wi-Fi home control**

Choosing the components and values

Transistor/Other Qty. Semiconductors:

LED 50

| | |
|---|---|
| BC547 | 10 |
| L7805 Regulator | 2 |
| Diode 1N4007 | 2 |
| Temperature Sensor Dellas 18b20 | 1 |
| Light dependent resistor | 1 |
| Microcontrollers: | Qty. |
| Arduino Nano | 1 |
| Esp32s Microcontroller | 1 |
| Esp32 Wi-fi CAMERA | 1 |
| Other Components: | Qty. |
| 4 Channel Relay Module | 2 |
| A6 mini GSM Module | 1 |
| Buck Converter | 1 |
| Power Switch | 1 |
| Veroboard | 1 |
| Battery 12V 7.2Ah | 1 |
| Jumper Wire | 40 |

## Testing and Construction

This section explains the construction, testing procedures and tools used in carrying out this study.

### Tools used for Testing

**Digital Multi-meter:** multi-meters are basically devices for measuring voltage, resistance of resistors, continuity and current. It has two types; Analog and Digital multi-meter. The process of implementing the design on a project board required the measurement of resistance at each stage, voltage drop or gain, continuity, current and in some cases frequency measurement. Thus measurements were done using a digital multi-meters.

**Bread Board:** A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holesand then making connections through wires where appropriate.

**Power Supply:** A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. The power supply unit used for this project testing was a 12V battery.

**Jump Wires:** A jump wire (also known as jumper wire, or jumper) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used tointerconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

**LEDs:** An LED lamp or LED light bulb is an electric light for use in light fixtures that produces light using one or more light-emitting diodes (LEDs).

**Arduino IDE:** The Arduino integrated development environment (IDE) is a cross- platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

**Android Mobile Phone:** An android mobile phone is smart phone that uses Android operating system. Android is a mobile operating system developed by Google. It is based on a modified version of the Linux

kernel and other open source software, and is designed primarily for touchscreen mobile devices such as smartphones and tablets.

**Prototype Testing**

**Figure 3.1: complete setup for prototype testing**

**Testing the ESP32**

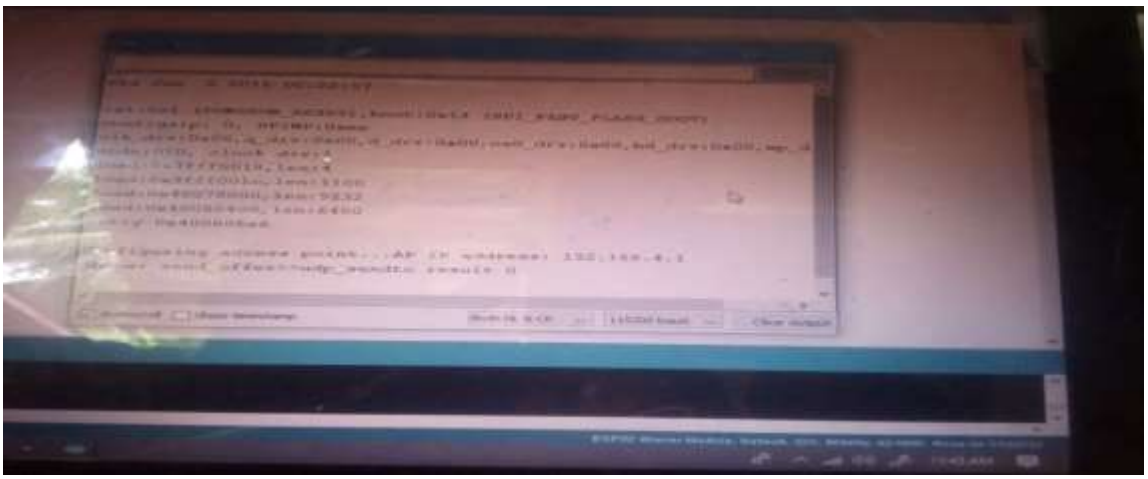

**Figure 3.2: program code uploaded into the ESP32**

After the above program code was uploaded into the ESP32, the ESP32s microcontroller created hotspot connection known as 'GAME' for users to connect. We proceeded to test the android device connection with

the WiFi. The connection was established and an IP address was displayed on the serial monitor to be connected to any browser.

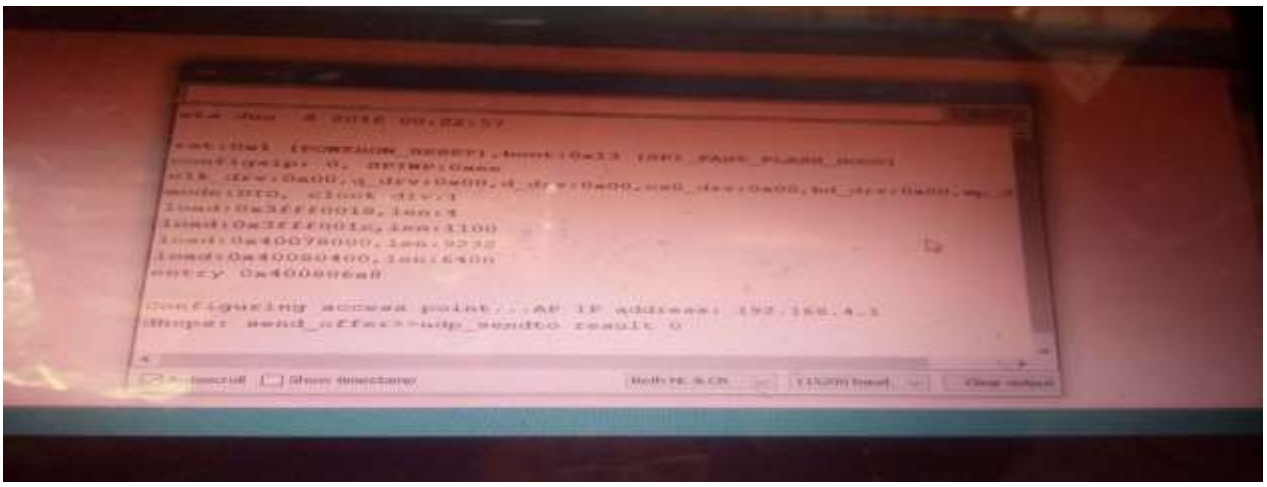

**Figure 3.3: IP address displayed on the serial Monitor.**

And access to the Smart-home automation page was established using the username "game" and password "game" as seen below.

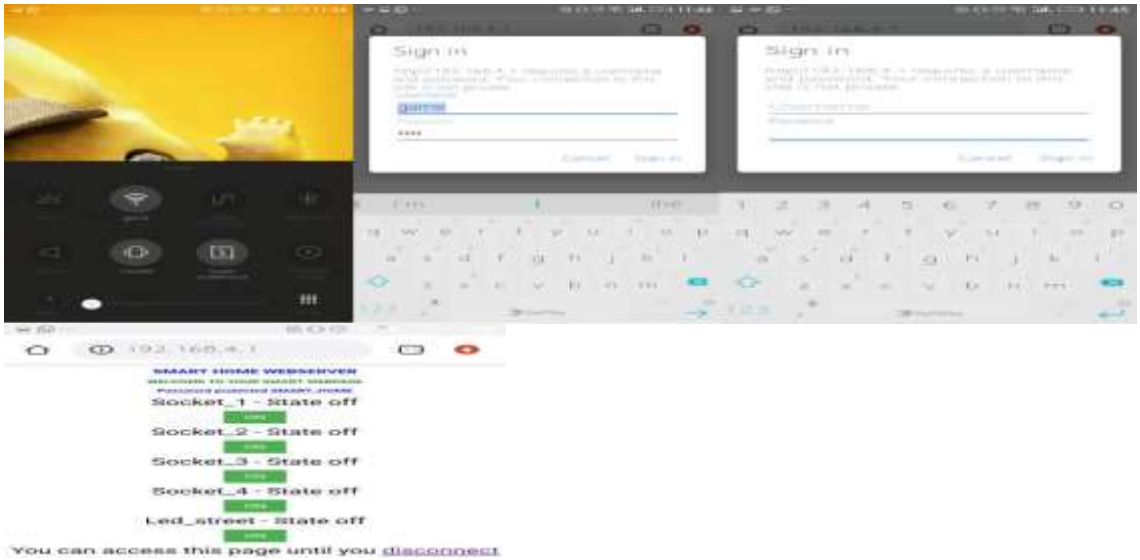


**Figure 3.4: Webpage of the smart-home appliance button.**

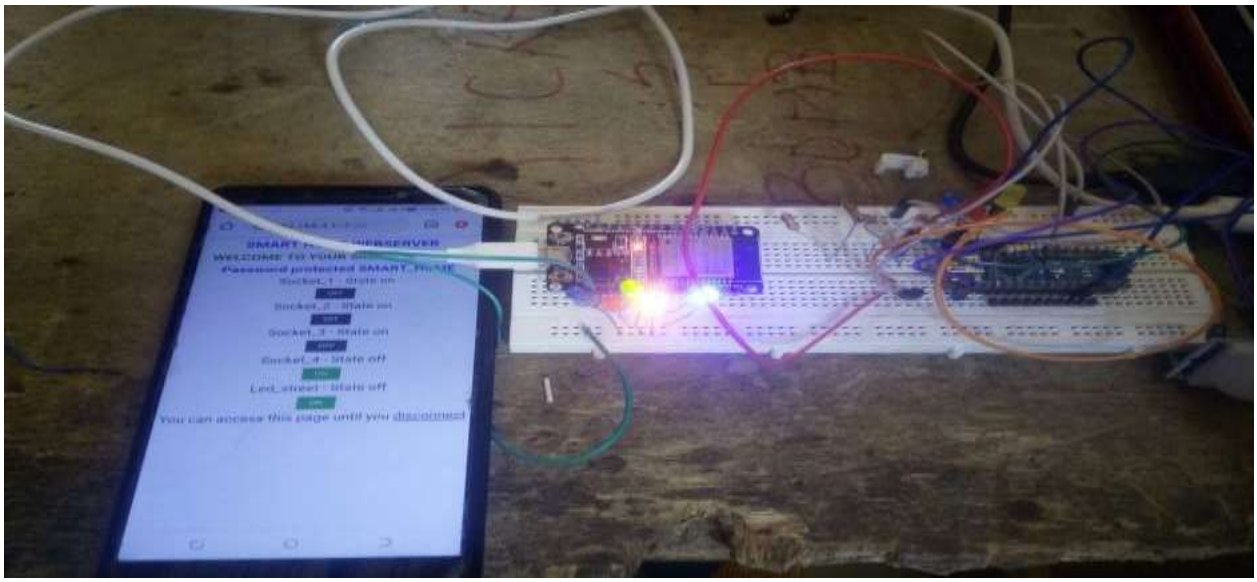

**Figure 3.5: Wi-Fi mobile control of appliance through webpage.**

### Testing of the Sensors with the Arduino

First we connected the Arduino on the bread board, then connected the temperature sensor, PIR sensor and LDR. It was observed during our testing that it required 4- 10 seconds for each sensor to respond.

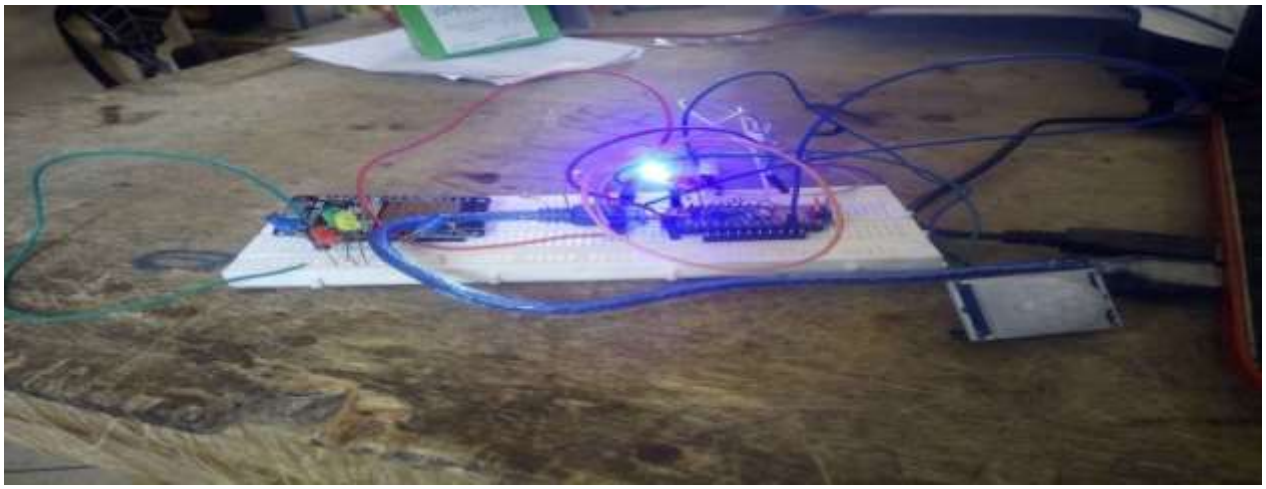

**Figure 3.6: Motion detected and the blue Led turns ON when PIR sensor senses motion**

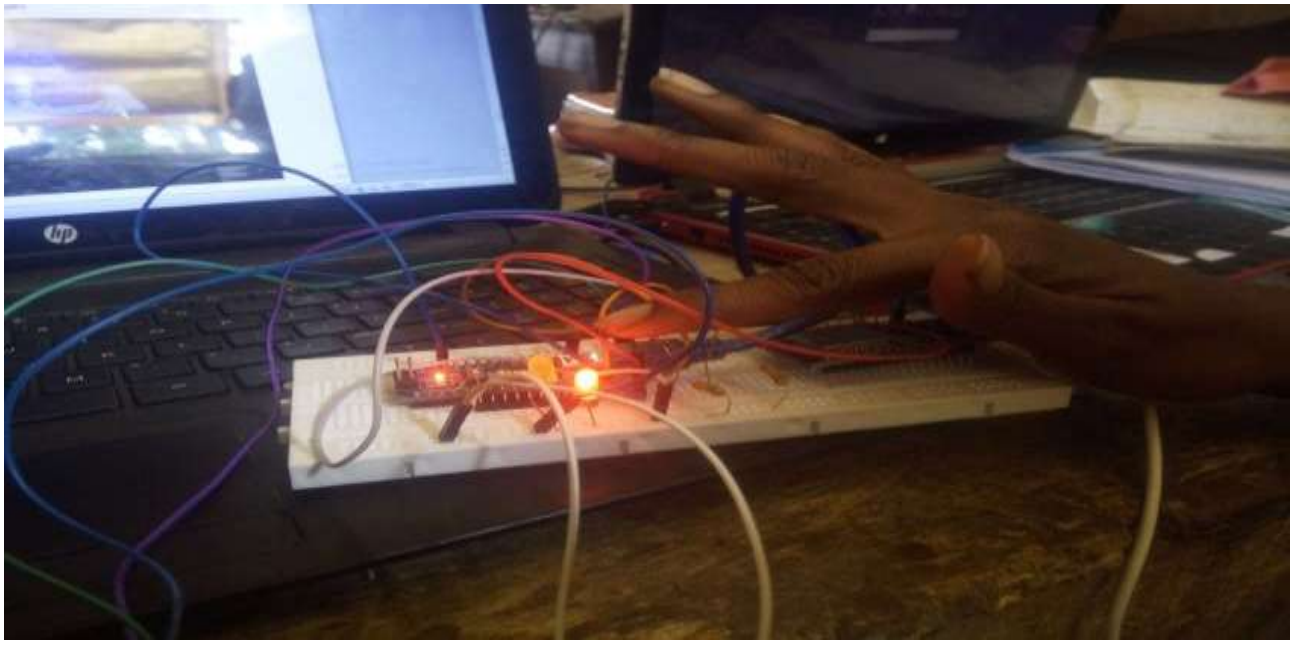

**Figure 3.7: Red LED turns ON when light dependent resistor is covered to simulate darkness**

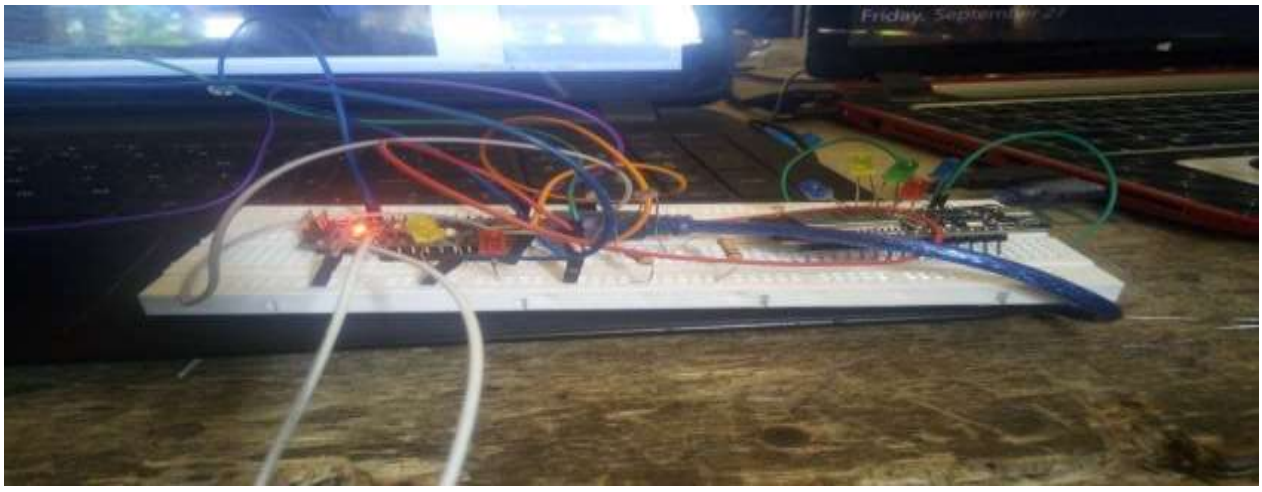

**Figure 3.8: Red LED turns OFF when light dependent resistor is uncovered to simulate day.**

**Results from prototype test**

| MCU | Wi-Fi range | Wi-Fi radioand baseband | Clock speed | Internet speed | Power consumption |
|---|---|---|---|---|---|
| ESP 32s | 20 meters | 802.11b/g/n | 20MHz – 40MHz bandwidth | 80MHz | 30mA – 60mA at 5V |

**Table 3.9: Result of the ESP32s test**

| S/N | Sensors | Power | Sensitivity | Range | Power consumption |
|---|---|---|---|---|---|
| 1 | PIR sensor | 5V | Heat radiation | 10 meters | 15mA |
| 2 | Light dependent resistor | 5V | Light and darkness | 3cm | 1mA |

**Table 4.0: Result of sensor test**

**Tools used for Construction**

**Soldering iron:** this is an electrical heating tool used for joining components and devices on a board using soldering lead. They are rated in watts and are commonly seen in the market is the 60 watts' type. During this study construction, a 25watts soldering iron was used to avoid overheating of components.

**Lead solder:** solder is a metal or alloy that melts at a low temperature. There are two types of solder; soft solder and hard solder. Soft solder melts easily with soldering irons and is used for electronics and electrical work. There are two main types of soft solder; lead solder and lead-free solder. The lead solder was used throughout this study.

**Cutter:** this is a tool for cutting cables and reducing the length of component leadsbefore and after soldering.

**Long nose pliers:** this is a type of pliers with long teeth, used for holding, picking or twisting cables

and components before and after soldering.

**Vero board:** A Vero board is a brand of stripboard, a pre-formed circuit board material of copper strips on an insulating bonded paper board. It is used as a general-purpose material for use in constructing electronic circuits.

**Lead sucker:** a simple device that applies the principles of a vacuum pump, used to suck or remove excess lead from the board ensure neatness of the work.
Steps Taken During Construction

**STEP ONE:** sourcing of components and the necessary tools that will be needed to ensure time management during the design.

**STEP TWO:** testing of the various components using a meter to ensure proper functionality and maintain specification.

**STEP THREE:** mounting of components on the project board, checking of connection to avoid short circuiting.

**STEP FOUR:** pre-testing of the assembled components on a project board, reading at various stages to ensure functionality and some adjustments were made.
**STEP FIVE:** transfer of the components to a Vero board and the house model, thensoldering of joints as required. Proper care was taken at this stage.

**STEP SIX:** testing of the soldered components and components installed on housemodel. Then finally casing and retesting to make sure no part is affected.

**Figure 4.1: control hub and base of the compound**

**Figure 4.2: Side view of the prototype building with all electrical components installed**

**Figure 4.3: Front view**

## CONCLUSION AND RECOMMENDATION

### Conclusion

In this work, a design concept for a wireless real-time home automation system based on Arduino Nano microcontroller as central controller has been obtained. The proposed technique provided that the automated system has two operational modes, where the first mode used a manually-automated mode technique in which users can monitor and control their home appliances from anywhere over the world using cellular phone through Wi-Fi communication technology.

The second mode was a self- automated mode that made the Arduino Nano controller capable of monitoring and controlling different appliances in the home automatically in response to any signals from related sensors. A hardware implementation of the system was carried out to verify the reliability of the system. The implemented system was simple, low cost and flexible that can be expanded and scaled up.

**Recommendation**

This project was designed using three sensors and it includes connection through a personalized Wi-Fi. This means that control of appliances can be done from within the home only. The following are the recommendations for future improvement:

- More sensors and internet connectivity; This will enable home owners to control appliances from anywhere in the world.
- Increased appliances to be controlled.
- Designing a software application for easier accessibility.
- Implementation of a stand-alone solar system.

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